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BODY BUILDER INFORMATION

The Incomplete Vehicle Document (IVD) is supplied with each incomplete vehicle, and provides information that should be used by intermediate and final stage manufacturers in determining conformity to applicable Federal Motor Vehicle Safety Standards (FMVSS). The IVD also includes information which must be followed in order to ensure that Environmental Protection Agency (EPA) and California emissions certification requirements and NHTSA Fuel Regulations are met.

This Body Builders Book contains information that may be used in addition to the IVD for any manufacturer making alterations to an complete/incomplete vehicle. No alteration should be made to the incomplete vehicle which either directly or indirectly results in any component, assembly or system being in nonconformance with any applicable Federal Motor Vehicle Safety Standard or Emission Regulation. Intermediate and final stage manufacturers should be familiar with all Federal Motor Vehicle Safety Standards and Emission Regulations and aware of their specific responsibilities as manufacturers.

For further assistance contact Upfitter Integration at: 1 (800) 875-4742, or go to our Web site at **"http://www.gmupfitter.com."**

Section 0 – General Instructions

Check for proper clearance between body members and chassis components which may in any way affect the reliability and performance of the vehicle by developing abrasion and wear points from moving parts or degradation from extreme environment or thermal exposure or may increase interior noise.

Check headlamp aim and all vehicle illumination systems for proper operation when the vehicle has been completed. Re-aim headlamps when necessary. Check for proper operation of windshield washer, wipers and defroster system.

Extreme care must be taken when working on vehicles equipped with Brake Control Module (BCM), Engine Control Module (ECM), Transmission Control Module (TCM). (See Owner's Manual.)

If arc-welding is performed on the chassis, precautions must be taken to protect all vehicle components, especially brake, fuel lines and fuel tank assembly, electrical wiring and BCM/ECM/TCM. (To avoid electronic component damage, disconnect battery (batteries); disconnect the negative cable first, followed by the positive. To reconnect cables; connect the positive first, then the negative.)

All labels on the vehicle (any message applied to the vehicle or vehicle component that informs, instructs, or warns) must appear on the completed vehicle so the user can read them easily and without obstruction.

Service and service replacement parts for your add-on systems may not be available from a GM dealer. Those installing aftermarket systems should provide information as to where and how to obtain service and replacement parts.

(Section 0 – continued on next page)

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When installing a Power Take-Off (PTO) with hydraulic lines, the following care should be exercised:

- Route and secure all hydraulic lines so that they are not in close proximity to any parts of the exhaust system. Keep all fittings and connections away from the exhaust system. Make sure connections and fittings cannot leak on the exhaust system.
- Exhaust system heat can damage and degrade hydraulic lines and components. Oils and hydraulic fluid coming in contact with a hot exhaust system could result in a fire.

Section 1 – Body

Body structures, interior and accessory arrangements must be designed into the vehicle to provide for proper load distribution on both axles and not to exceed any gross axle weight ratings. Lateral load equalization must also be maintained. The resultant Center of Gravity of the unladen vehicle must be within the limits tabulated in the FMVSS 105 and FMVSS 121 section of the IVD.

Body insulation provided by General Motors should not be removed. This includes any thermal or underbody heat shields. This insulation is provided to protect hoses, seals, components, body and occupants from excessive heat and/or provide noise attenuation. Any replacement material internal to the occupant compartment must be certified for MVSS standard on flammability. Areas of specific concern, but not limited to, are:

- Underbody exhaust, muffler and tailpipe shields and insulators.
- Rear load floor interior insulation.
- Front floor interior insulation.
- Dash mat insulation.
- Engine cowl insulation – interior and exterior.
- Engine cover insulation.

Accessory items, such as refrigerator, hot water heater, furnace, etc., which operate on liquid propane gas should be located and protected to prevent exposure to any flame.

(Section 1 – continued on next page)

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Seating

If a bodybuilder installs seating other than that supplied with the vehicle, it is the bodybuilder's responsibility to ensure that the seating and restraint systems comply with FMVSS requirements. The restraint systems supplied with the vehicle were designed to accommodate the seating reference points and seat travel of the original equipment seats only.

Section 2 – Frame

Hole drilling, welding, modifications, or alterations to the frame assembly are the responsibility of persons performing these operations. These same individuals assume complete responsibility for frame assembly reliability, performance after alterations and compliance to applicable FMVSS requirements.

The following procedures and specific precautionary instructions are recommended for proper installation of special bodies and/or equipment on GM frames. Failure to follow these recommendations could result in serious damage to the basic vehicle.

Flanges

Do not drill holes in frame flanges.

Holes

Holes to mount brackets, supports, and out-riggers must be drilled in the vertical side rail web with the following restrictions:

- The minimum edge distance between any two (2) holes must be larger than twice the diameter of the larger hole.
- No holes should exceed 20 mm (0.75 in.) in diameter.
- All holes should be drilled in the frame using appropriate drilling practice and safety precautions – no more than four (4) holes in a row vertically.

Welding

CAUTION: Fuel tank and fuel lines must be drained and all vapors purged to ensure noncombustible mixture before any welding, brazing or soldering.

(Section 2 – continued on next page)

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No welding is permitted on Family 3 heat-treated frames.

When welding side rails, crossmembers and brackets (50,000 or 80,000 PSI yield strength), emphasis is placed upon weld application techniques to avoid stress risers that may adversely affect frame operating stresses.

When welding is performed anywhere on the vehicle, precautionary measures should be taken to prevent damage to electrical system wiring or components. Prior to any welding, parts or components which could be damaged by excessive temperatures must be removed or adequately shielded; the battery cables should be disconnected at the battery. Also prior to welding, the area to be welded and surrounding area must be cleaned of all frame protective coating. After welding, when parts are cool, carefully inspect wiring and electrical components for shorts or other damage which could draw excessive currents and possibly cause an electrical system short when the battery is reconnected. Apply protective coating equal to the original finish to areas where coating was removed.

Alterations

If the wheelbase is modified, the alterer must take responsibility for compliance with affected motor vehicle safety standards and also for warranty on items such as driveshafts, universal joints, center bearings and rear transmission tailshaft, transfer case and transmission case fractures, output shaft bushings, bearings, brakes, brake lines, fuel systems, and any other related component failures and that the Anti-lock Brake System (ABS) Module may require reprogramming. Additionally, the customer must be alerted in the modifier's owner's manual that parts for the reworked area are not available through the General Motors service parts system.

NOTE: After any alterations, make sure to check for leaks.

Shear Plate Attachments

Attachments of shear plates should be accomplished by using existing manufacturing holes already available in the frame side rails. Manufacturing holes, normally 19 mm in diameter, are placed along the frame side member in the center of the web on each frame.

When additional holes are required for shear plate attachment, they should be no larger than 20 mm (0.75 in.) in diameter. Holes are to be drilled no closer than 63.5 mm (2.5 in.) apart. For holes drilled forward of the rear axle, centers are to be no closer than 63.5 mm (2.5 in.) from the top or bottom flanges and no closer than 89 mm (3.5 in.) from any suspension attachments. For frame holes drilled rearward of the rear axle, hole centers are to be no closer than 51 mm (2.0 in.) from the top or bottom flange and no closer than 89 mm (3.5 in.) from suspension attachments.

No additional holes or notching of either top or bottom frame flanges are allowed.

In addition, the frame integrity should be maintained.

Section 3 – Front Suspension

See chassis data information for clearances and assistance in calculating trim heights.

Since there is a large variation in completed vehicle front weight due to differences in body weight and equipment, the front suspension alignment must be checked and reset if necessary after the vehicle is completed. Caster should be set with reference to the "A" dimensions. Camber is designed into the axle and cannot be adjusted.

See Truck Service Manual for complete alignment procedure, for specifications and measurement of the "A" dimension under "Diagnosis and Front Alignment" section.

Section 4 – Rear Suspension

Clearance to body should be provided for the suspension, axle, driveshaft and tires under the following conditions: (1) Axle in full jounce against the metal-to-metal stop, (2) Axle at 4.5° roll with one side of axle in full jounce at the metal to metal stop and (3) Axle at design position. Allowance for the tire chain clearance shown on a maximum grown tire must allow for (1.66 in.) clearance to the sides of the tire and (2.5 in.) to the top of the tire. Be sure sufficient clearance is provided for suspension, axle and tire and wheel in full vertical travel (up and down).

NOTE: Notification to the consumer may be required in certain states if tire chains cannot be used.

Pipes, wiring, conduits and any other related components must not be placed where they cross the path of motion of the rear axle, driveshaft, axle brake pipes, hoses, spring or tires. Such crossing could result in rupture, wear-through, or separation due to normal axle motion.

NOTE: Any alteration to wheelbase or tire rolling radius may require re-programming of the ABS module.

See chassis data information for additional clearances and for assistance in calculating trim heights.

Section 5 – Brakes

See Truck Service Manual for brake specifications.

Due to the critical nature of brake systems, anyone making modifications or alterations must assume complete responsibility for system reliability, performance and certification to FMVSS 105 or FMVSS 121.

(Section 5 – continued on next page)

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It is mandatory that no change be made to the brake main cylinder location, brake pedal push rod length or pedal position.

Ensure that hydraulic brake system is free of air and hydraulic leaks. Bleed brakes if required following procedures as outlined in the Truck Chassis Service Manual. Ensure that the vacuum booster system or Hydroboost/Hydromax system is functional and free of leaks.

Check master cylinder fluid level and fill as necessary. (Refer to Owner's Manual.)

Check power steering fluid level for models equipped with Hydroboost or Hydromax brake. (Refer to Owner's Manual.)

Added floor covering or carpeting must not restrict service or brake pedal travel from released position to full pedal travel.

No body part or chassis-mounted component may be located within 2.0 in. of brake hose routing in all wheel and axle positions. All exhaust system components must also have a minimum of 2.0 in. clearance to brake hoses in closest positions. (Be sure to account for brake hose travel with suspension.) All ABS sensor wiring routing must not be altered or secured in locations other than as installed.

Body builder is to verify that the brake warning switch is operative.

Air Brake Systems

When any air-operated equipment is added to the vehicle, it is mandatory that a pressure protection valve be installed between such equipment and the main air supply to prevent loss of air to the brakes.

No body parts or chassis-mounted component may be located within 2.0 in. of brake hose routing in all wheel and axle positions; be sure that brake hose travel is accounted for. All ABS sensor wiring routing must not be altered or secured in locations other than as installed.

Chassis heat shields, added by the original manufacturer, should not be removed. Any air brake lines added or revised that are near the exhaust must be shielded.

Section 6 – Engine

For additional information refer to ***Section 1 – Body.***

Air conditioning and auxiliary belt-driven equipment installation recommendations:

No alterations or additions to the accessory drive belt system will be warranted on either multiple belt systems or serpentine belt systems.

(Section 6 – continued on next page)

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Multiple belt systems may incorporate several conventional V-belts, or a combination of conventional-V and poly V-belts. If modification to this type of system is made, the following should be considered:

- The addition of a pulley sheave forward of the production sheaves may subject the crankshaft and water pump bearings to loads beyond the desired limits.

- Generally, an added load is preferable in the first belt track closest to the engine to minimize the overhang moment effect on bearings.

- Heavy or improperly balanced pulleys may contribute to bearing failure because of load, induced by their mass and/or unbalance. It is extremely important (especially on the water pump) to have well-balanced and concentric pulley sheaves in order to avoid premature bearing failure. Pulley unbalance must not exceed 0.25 oz. in., and lateral and radial runout must not exceed 0.010 in. in T.I.R.

- The fan, fan clutch and fan drive ratio (fan pulley diameter crankshaft pulley diameter) that come with the vehicles are matched to the equipment and conditions encountered in normal operation. Substitution of the fan and/or fan clutch and fan drive ratio will affect cooling performance. A substitute fan will be subjected to excessive stresses and might break. Substitution is therefore not allowed.

- The incorporation of an aftermarket air conditioning system could have the following consequences:

  – Vehicle/engine/coolant overheating in certain geographical areas that normally experience high ambient temperatures.

  – Restrictions to engine cooling fan airflow resulting in higher fan blade stress.

  – Inadequate air conditioning performance unless system capacity is enough to cool the interior space of the completed vehicle.

- Addition or relocation of items in front of or behind the arc of the fan blade travel, or changes to fan fore and aft location relative to accessory drive, will alter fan stresses, and could contribute to fan blade failure. Moving the fan and/or clutch forward is also likely to overload the water pump bearing.

- The addition of air conditioning could affect conformance to FMVSS 301-Fuel System Integrity. The added equipment, in the event of an accident, could be displaced into and possibly rupture fuel system lines, hoses, filters and equipment. Care must be taken not to affect such conformance.

(Section 6 – continued on next page)

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- The curb weight of the vehicle will be affected by the weight of the added system.

In multiple belt systems, belt tension must be measured using either a mechanical gage (such as Borroughs or Kent-Moore) or an electronic gage (G.S.E. or Beta-Tech). Each gage model is calibrated for a specific type and size of belt: E.G., 3/8 in. V, 4-rib poly-V, 6-rib poly-V, 1/2 in. V, etc. Therefore, it is necessary to follow the gage manufacturer's usage instructions to get correct readings. Refer to the appropriate shop manual for tension settings.

Original equipment poly-V serpentine belt drive systems that use a spring loaded automatic tensioner do not require belt tension adjustment. If the belt is replaced, use only the belt specified by GM for the replacement. Even though an aftermarket belt is the same length and it has the same number of poly-V ribs, the belt cord material and construction may be different, and this can result in improper belt performance.

Due to the critical nature of the accelerator system, anyone making modifications or alterations assumes complete responsibility for system reliability, performance and compliance to FMVSS 124.

- Caution must be taken so that the accelerator pedal remains properly located. Guidelines for accelerator pedal locations are as follows:
  - Ensure that the accelerator can freely operate from idle to wide-open throttle position and return. Make sure that the pedal will not hang up on any nearby items such as carpets, floor, screws, wiring harnesses, etc. Engine cover should have at least one inch (25 mm) clearance to side of accelerator pedal with the carpet mat installed.
  - Accelerator to brake pedal relationship has been designed to provide minimum driver movement and should not be altered in any way.

Gasoline engine air induction, exhaust and cooling (fan) system is certified and in compliance with the Federal Vehicle Noise Requirements.

Gasoline engine air induction and/or ignition system is certified in compliance with the Federal Vehicle Emission Standards. Any alterations to the systems or components could void compliance and render the vehicle illegal. System includes:

- Fuel system – central port injector (CPI) and associated tubes, hoses and pipes, air cleaner outside air hose and spacer heat stove and heat stove pipe, fuel pump and inlet manifold, fuel vapor canister.
- Cooling system – fan, fan clutch, drive and driven pulleys.

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- Exhaust system – muffler, cat. convertor, piping (sizing).
- Air Induction system – air cleaner, duct work.
- Ignition system distributor and initial spark timing setting, spark plugs, spark plug wires.
- Crankcase ventilation system.
- When a vehicle is equipped with an electronic fuel injection (EFI) engine, it has an engine control module PCM. This PCM must be maintained at a temperature below 185ºF at all times. This is most essential if the vehicle is put through a paint baking process. The PCM will become inoperative if its temperature exceeds 85ºC or 185ºF. Therefore, it is recommended that temporary insulation be placed around the PCM during the time the vehicle is in a paint oven or undergoing another high temperature process.

Diesel engine induction and injector pump system is certified to be in compliance with the Federal Vehicle Emission Standards and/or Noise Standards. Any alterations to the system or components could void compliance and render the vehicle illegal. System includes:

- Fuel system – Injection pump, injector lines and injectors, fuel return hoses and pipes, air cleaner, outside air hose, fuel pump, fuel filter, fuel heater assembly and intake manifold.
- Exhaust system.
- Crankcase pressure regulation system.
- Charge air cooler system.
- External engine components such as air cleaner, crankcase pressure regulator valve, alternator, injection pipes, fuel return hoses from injectors, exhaust manifolds, oil fill pipe, etc., must be provided with sufficient clearance for engine roll and torque.
- When a vehicle is equipped with a direct injection (DI) engine, it has an engine control module ECM. This ECM must be maintained at a temperature below 85ºC or 185ºF at all times. This is most essential if the vehicle is put through a paint baking process. The ECM will become inoperative if its temperature exceeds 185ºF. Therefore, it is recommended that temporary insulation be placed around the ECM during the time the vehicle is in a paint oven or undergoing another high temperature process.

Section 7 – Transmission

Models equipped with automatic transmissions have neutral/park start safety mechanical lockout feature, which interfaces with the steering column ignition switch. Starter should operate only when gearshift lever is in neutral or park position. Readjust the shift linkage if necessary as outlined in the Truck Service Manual.

Power Take-Off (PTO) systems refer to ***Section 0 – General Instructions.***

- In instances where it is necessary to drain and refill or add fluid to the transmission, such as when installing PTO, ***DO NOT*** substitute any other lubricant. Installation of other lubricants may result in internal transmission damage. (Refer to owner's/ service manuals for specific information.)

- Models equipped with Eaton manual transmission have synthetic lube installed as the factory fill. When the transmission is drained for PTO installation, it must be refilled with synthetic lube GM P/N 12345724 or Eaton approved 50 weight synthetic gear lube.

Section 8 – Fuel and Exhaust

Fuel Systems

Due to the critical nature of sealing the fuel system, anyone making modifications or alterations to the existing system must assume complete responsibility for the system reliability, performance and compliance to Government Regulations.

The fuel evaporative emission control equipment is certified to be in compliance with the Federal and California Vehicle Emission Standards. Any alterations to systems or components and their location could void compliance. The system includes:

- Fuel tank, metering unit, lines including purge control solenoids and canister or canisters.

For these reasons, **NO ALTERATION OF THE FUEL SYSTEM IS RECOMMENDED.**

Temporary Tank

The temporary fuel container and sender unit must be replaced with a permanent fuel tank assembly prior to placing the vehicle into use. The replacement tank supplier and/or body builder is responsible for certifying evaporative emissions.

NOTE: If a temporary tank fuel sender unit is used with a permanent fuel tank, the Body Builder must assure that there is not degradation of the fuel system integrity and performance.

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Fuel Lines

Fuel line routing precautions:

- When using non-metallic fuel lines, operating environment should not exceed 194ºF continuous and 239ºF instantaneous.
- 12 in. minimum clearance to exhaust system is required or a metal shield must be provided.
- Fuel lines should be clipped to chassis to prevent chafing. Metal clips must have rubber or plastic liners.
- Use corrosion resistant steel tubing with short sections of approved hose to connect components. Hose-to-tube connections should be clamped for diesel systems. Steel tube ends should be beaded for hose retention. Fuel supply is pressurized by an in-tank pump for gasoline systems. Coupled hose connects must be used. Clamped hose is not acceptable for gas fuel systems.
- Non-metallic fuel lines cannot be altered.
- When using non-metallic fuel line components, all the components must be conductive to maintain ground.

All engines require a fuel return system which returns excess fuel from the injection pump and injector nozzles back to fuel tanks. Care should be taken that these lines are not blocked nor their hoses pinched. The engine may run poorly or stall if these lines are restricted or blocked.

All gasoline engine vehicles are equipped with fuel evaporative emission control equipment which is certified to be in compliance with the Federal or applicable California vehicle emission standards. Alterations to fuel tank and metering unit, lines, canister or canisters, canister filters, canister purge control valves, relay switches, tank auxiliary vent valve, engine speed controller, or other devices/systems are therefore not allowable since vehicle adherence to C.A.R.B. and Federal regulations may be affected.

Diesel powered vehicles may incorporate water drain provisions in the fuel system. These valves are only to be opened when eliminating water and contaminants from the fuel system.

Fuel Tank

The tank must have a minimum clearance of 2 inches from top, front, rear and sides to body and other supports.

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Tank may be pressurized temporarily to 1.25 psi maximum to check for final line leakage or for forcing fuel through the system. Pressures greater than this amount may be detrimental and affect tank durability.

The use of auxiliary fuel tanks is not recommended. If an auxiliary fuel tank is added, the alterer must take responsibility for compliance with affected Federal Motor Carrier Safety Regulations and other motor vehicle safety standards. Also, if an auxiliary fuel tank is added to a gasoline-powered vehicle, the fuel must be drawn through a pipe at the top of the tank (balance line between tanks is not permitted).

All vehicles are now equipped with a fuel return line. If an auxiliary tank is added, the tank selector valve must include a return port which returns fuel to the tank from which the fuel is being drawn.

In gasoline engines, the fuel pump is located in the fuel tank. The battery must be disconnected before starting any work on the fuel system.

In the use of dual fuel systems, the vehicle operator should strictly adhere to the manufacturer's procedures for switching from gasoline to gaseous fuel operation. Improper switching procedures may result in overheating and damage to the exhaust system and the vehicle. The gaseous fuel tank should not be mounted in an enclosed area of the vehicle, such as the passenger compartment, trunk, etc., and the system should be vented to the outside of the vehicle. In addition, vehicles converted to gaseous fuels should not be stored in enclosed places such as garages. Further, General Motors cautions purchasers that the design, location and installation of any type of fuel storage system involves significant technical and engineering considerations and that these statements on gaseous fuel conversions should not be interpreted to be an approval by General Motors of any modification to the original equipment fuel system.

Conversions to gaseous fuel should be made in conformance with applicable Federal and State regulations. Removal of emission-control components, or the addition of gaseous fuel systems which could damage or reduce the longevity of those components, could also cause the mechanical and emission performance warranty to be voided.

Exhaust System

Particular care should be taken to prevent the possibility of exhaust fumes and carbon monoxide exposure to vehicle occupants in units completed by body builders. Holes and openings through the floor and all other parts of the body must be permanently and adequately sealed by the body builder to avoid exhaust intrusion into any occupant area. If it is necessary to change the exhaust outlet location, the exhaust discharge must be unobstructed and directed away from occupant areas. Alteration of the exhaust outlet or its position may increase exhaust noise and render the vehicle illegal in those areas with pass-by noise regulations. All vehicles >10,000 lbs. GVWR come under Federal noise regulations of the Environmental Protection Agency; see those regulations for rules, test procedure and noise levels permitted.

Tailpipe outlet location must be tested statically and with the vehicle in motion to ensure that exhaust gases do not penetrate side or rear windows or underbody seams and holes. Auxiliary power plants should also be tested under the same conditions. Tailpipe extension must extend 2.0 to 2.5 in. outboard of body side panels. Tailpipe exit ahead of rear wheels is not recommended.

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Check for leaks in exhaust systems and repair as required.

Exhaust temperatures can exceed 1600ºF under extreme operating conditions, with pipe surface temperatures slightly less than this. Extreme care must be used when placing body components in the proximity of the exhaust system so as not to exceed the rated temperature limits of the components. Due to variants in underbody configurations of the vehicles, we are not in a position to make recommendations on how to insulate or design components in the proximity of the exhaust system.

Each manufacturer must make temperature checks of critical areas of his vehicle and adjust his design accordingly, or provide shielding to ensure safe operation of his body components.

The same can be said for the engine compartment. Obviously there will be additional heat radiated from the engine. How much is retained in the area will depend on how well this area is ventilated in your individual designs. Here again, temperature checks of interior areas surrounding the engine should be made to determine if your insulation is adequate. This is the same engineering practice we have followed on our complete vehicles incorporating these exhaust systems.

Exhaust system materials are selected and tested to withstand the operating environment of the vehicle. Do not modify the exhaust system in any way. The tailpipes are made of 409 stainless steel or aluminized steel.

Heat shields are mounted to the underbody and/or exhaust system components (catalytic converter and muffler). Shields for the propshaft hanger bearings are also provided in some vehicles.

Section 9 – Steering

Check power steering fluid level and system operations. ***(Refer to Owner's Manual).***

Steering wheel and horn pad must not be altered or replaced.

The steering column mast jacket must not be altered.

Section 10 – Tires

Check wheel lug nuts for proper torque; specifications are provided in the Owner's Manual.

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Substitution of tires of greater capacity than those offered as original equipment by vehicle manufacturer is not approved for use on original equipment wheels. Any usage of higher capacity tires must be accompanied by higher capacity wheels with the same type mounting and fasteners. However, the wheel offset and distance from centerline of rim to wheel mounting face must be the same as the replaced original equipment wheel to ensure proper wheel bearing loading and clearance of tires to body and chassis components.

Increasing tire and wheel capacity does not necessarily increase vehicle GVW ratings.

It is recommended that tire chain clearance guideline J683 from the Society of Automotive Engineers be adhered to in designing rear wheelhouse clearance.

Check tires and inflate to recommended tire pressure according to the tire inflation label provided with the vehicle (as referenced in the owner's manual).

Any substitution of tires may affect Speedometer/Odometer accuracy.

Section 12 – Electrical Battery and Battery Cables

The vehicle battery should be located and positioned to make use of the existing battery cables. If the battery requires relocation and longer cables are required, a proportionately larger gauge wire must be used. If in relocating the battery the negative ground cable is attached to the frame rail, a cable of similar gauge must be provided between the frame rail and the engine. This is required due to the heavy electrical loads imposed by the starting circuit. To ensure proper operation of the battery cables the following chart on length, gauge and materials must be strictly adhered to:

Gasoline Engines

Combined Length of Positive and Negative	
Cable Gauge	**Cable in Inches (Copper)**
4	66
2	107
0	170

(Section 12 – continued on next page)

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Diesel Engines

Any increase in battery cable lengths, from the General Motors design, should change to 000 cable gauge.

Battery Installation

The battery and cable installation, provided by the body upfitter, must comply with the following guidelines. Non-compliance may result in a failure of the vehicle electrical component system, the shutdown of the engine, loss of backup brake system and the possibility of fire.

1. The cables must not contact any sharp edge(s), in either the normal (stored) or slid (maintenance) position (school bus application).

2. The cables must not be bent in a radius of smaller than 10 times the cable diameter. Insulation failure can occur if this happens.

3. The cable must be supported by clips spaced at a distance of not more than 450 mm, where possible. In this clipping, they shall not have a free movement that will allow rubbing on any vehicle component, either fixed or moveable.

4. All clips used must be of the rubber-lined type, not rubber-dipped.

5. Do not splice the battery cables. Cable modifications can result in vehicle starting problems and loss of other key systems.

6. The cables must be clipped to the battery tray such that the cable pull loads are not transferred into the battery posts due to slide tray movement. Failure to do so can result in loose terminals, poor starting and battery failure. Battery acid leakage could result around posts not properly relieved of strain.

7. The cable attachments at the battery terminal must not cause undue strain at these connections. There should be no sharp bends in the cables adjacent to the connections. The cables should be routed down from the terminals rather than horizontally from the terminals to prevent a lever action that may loosen connections. Terminal corrosion inhibitors and other coatings should not be applied to the sealed electrical contact areas. Terminal torque of the sealed terminal shall be 10/20 N•m for side terminal batteries and 14/20 N•m for top post batteries.

8. Mounting Base (Tray) – The tray should be of substantial material (minimum 1.75 mm thick or sufficiently reinforced) to resist flexing and cracking. The tray must provide firm, continuous support of the battery and not amplify vibration levels. There must be no protrusions or projections in the tray or mountings that would damage the battery. Cantilevered mountings are not recommended and the tray should be mounted flat so as not to aggravate electrolyte spillage or lead fatigue. A rounded lip of adequate height to ensure stiffness and retention should be provided around the perimeter of the tray. With the battery mounted in a vehicle, a static force of 22 kg applied to a 6.54 sq. cm. area at any corner should not move the battery any more than .25 mm.

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9. Freedom Battery – The hold-down must be able to withstand a 22 G-3 millisecond shock loading and prevent the battery movement relative to the mounting base or hold-down. Torque at the battery hold-down shall be 15/20 N•m (133-177 lbs.-in.) at the base clamp or 2.3/4.5 N•m (20-40 lbs.-in.) at the top bar. A bottom hold-down centrally located at the sides of the battery is recommended.

10. Linehaul Battery – A tight, secure hold-down is essential. Hold-down brackets must retain the battery at a 22 G-3 millisecond shock loading. A top hold-down should be spaced a minimum of 15 mm from terminal posts to avoid possible ground paths. If a top hold-down is used, a non-corrosive, non-conductive coating is desirable.

    Location – The battery should be located in a well-ventilated area where a temperature build-up does not occur. The location should also provide protection to the battery to prevent damage from foreign objects. The ends of the battery in the area of the vent ports should be free of obstructions so that the gasses generated during charging can be freely dissipated into the atmosphere.

11. Vibration, Freedom Batteries – The mounting should not subject the battery to vibration levels in excess of a PSD of more than 0.8 G RMS for the frequency range 8 to 200 Hz in any axis when exposed to the Manufacturer's Driving Schedule. The mounted battery assembly shall not have resonant frequency lower that 50 Hz.

    Vibration, Linehaul – Battery(s) should not be subjected to peak vibration levels in excess of 3 Gs in any axis when exposed to the manufacturer's driving schedule. Vibration frequencies of 20 to 40 Hz will cause resonance of battery parts and should be avoided, particularly at levels above 1 G acceleration in horizontal directions. Vibration frequencies of 10 Hz or below with accompanying high displacements may cause electrolyte (acid) expulsion from the battery and should be avoided.

12. Accessibility – The hold-down should be convenient for tools and hands so that personal injury does not occur. There should be clearance at the insulated and grounded terminals so that wrenches can be used so that accidental grounds or shorts will not occur. Terminal polarity markings, warning labels and test hydrometer should be visible. The battery "ground" connection must be readily accessible for disconnection, as required for vehicle electrical service requirements.

13. Tilt Angles – For normal vehicle operation (at GVW), the battery should not be tilted (0º). For installation or removal, it should not be necessary to tip or tilt the battery in excess of 40º. This is to prevent acid spillage. For short duration vehicle shipment, do not tilt the battery more than 19º from the horizontal.

14. Temperature — The temperature of the electrolyte should not exceed 52ºC. Infrequent peak temperatures to 75ºC. can be tolerated in soak situations only. Shielding may be required to protect the battery from a source of excessive heat.

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15. Battery Trays — Battery trays are supplied with the chassis. In the case of motor homes and diesel school busses, the trays are secured to the frame rail (for shipping only).

    For other units, the tray is supplied on the radiator support. The trays shipped on the rails may be relocated to other areas on the vehicle, keeping in mind the recommendations noted above.

16. Battery Storage — Today's vehicles have several electronic devices which result in very small but continuous current drains on their batteries, commonly referred to as "parasitic" loads. Vehicles that are not used for an extended period of time may develop extremely discharged and/or permanently damaged batteries resulting from these parasitic loads. Discharged batteries can freeze at temperatures as high as 20ºF causing permanent damage.

    To alleviate this condition, check to make sure the green dot is visible, recharge as necessary, then disconnect the negative battery cable on vehicles which are not going to be in service within a 30-day period. If this is not possible, batteries should be recharged periodically (every 30-60 days) until the green dot is visible.

NOTE: The ignition switch must be off when connecting or disconnecting battery cables or hangers (jumper cables). Failure to do so may overstress or damage the ECM/PCM or other electronic components.

Modifications/add-on wiring must be carefully reviewed to ensure compatibility with the base vehicle wiring by reviewing system schematics, wire routing paths, harness connections, etc. Due to the wide range of modifications that may be required for vocational needs, it is not feasible for the O.E.M. to take into account all potential revisions. For this reason, any person modifying existing vehicle wiring must assume responsibility that the revisions have not degraded the electrical system performance. Any add-on wiring must be properly fused and routed to prevent cut, pinch, and chafe problems, as well as avoid exposure to excessive heat. Care must be exercised, that existing vehicle interfaces do not have their current load capabilities exceeded, and that the respective control devices are not overloaded. Added wire size should be at least as large as the the wire to which it is attaching in order for fuse protection to be maintained.

A Packard electric wiring repair kit is available through Kent-Moore (GM P/N 12085264, Kent-Moore P/N J38125-4). This kit contains instructions, tools and components for making repairs to wiring harness components. This kit would also greatly assist in accomplishing necessary add-on wiring such as body marker lamps, so that system reliability/durability is maintained.

Electrical wiring components can be obtained through your authorized GM dealer. Many Packard Electric components are also available through Pioneer Standard Company (1-800-PACKARD). Pioneer may also be able to assist in making necessary wiring additions by providing custom wiring stubs or jumpers to your specifications.

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Fusible Link Repair Procedure

1. Cut damaged fusible link from wiring harness assembly splice.
2. Strip insulation from harness wire as required to splice on new fusible link.
3. Fabricate a new fusible link wire approximately 6 to 8 in. long from the same wire size as the original link. (Acceptable fusible link material will be imprinted with the wire size and the wording to identify it as fusible link. Fusible link cable is not the same as normal vehicle wiring.)
4. Terminate fusible link harness wire with a suitable compression splice clip, and solder with an electrical grade rosin core solder. Wrap splice area with heat shrink tubing to provide electrical insulation, as well as mechanical strain relief at the splice.
5. Strip, terminate, solder, and insulate remaining end of fusible link with appropriate termination to be compatible with the rest of the electrical system.
6. For further information, refer to the instruction manual in the wiring repair kit referenced elsewhere in this section.

NOTE: A ground stud has also been provided above the junction block.

Accessory Power Supply Feed

Power for two-way radios should be obtained directly from the battery.

Section 13 – Cooling

To provide satisfactory engine cooling, the following conditions must be met:

1 . Do not locate any large objects in front of the radiator core or grille, such as batteries, spare tires, lights/sirens, etc. They restrict air flow into the radiator core and influence fan blade stress.

2. Grille opening, size configuration and the external baffles provided should not be altered in any manner. Any reduction in cooling ability may adversely affect engine/transmission performance.

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3. Fan clutches not conforming to the original equipment specifications will not operate correctly and will stay “on” continuously, never come on, or cycle on and off excessively. This will result in a reduction of fuel economy, engine overheat at times, and annoying cycling respectively.

4. Heavy-duty cooling equipment is required when air conditioning, auxiliary belt driven equipment, snow plows, winches, etc. are installed.

5. Grille open area must not be less than 85% of radiator core frontal area. The remaining 15% less blockage must be evenly distributed.

6. Continuous coolant flow is necessary from heater connection on engine to heater connection on radiator to control transmission oil temperatures during closed thermostat (warm-up) operation. Do not alter this flow as it may result in premature transmission failure.

When adding additional heaters, the system must be properly refilled to avoid air pockets. Use Dexcool coolant only.

When adding additional A/C equipment, the final refrigerant charge must be determined by the Body Builder. Use R134A refrigerant only.

Add-on units and lines should comply to ARI standards.